**BEFORE**
**THE DEPARTMENT OF AGRICULTURE – RURAL UTILITIES SERVICE**
**AND THE DEPARTMENT OF COMMERCE – NATIONAL**
**TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION**

**Broadband Opportunity Council**
**Notice And Request For Comment**

**DOCKET NO. 1540414365-5365-01**

# COMMENTS OF INTERNET2


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## Introduction

The University Corporation for Advanced Internet Development (d/b/a "Internet2") submits these comments in response to the Notice and Request for Comment ("Notice") issued by the Rural Utilities Service ("RUS") and the National Telecommunications and Information Administration ("NTIA") regarding the Broadband Opportunity Council ("Council").[1] The Notice raises a host of broadband issues, including modernizing federal regulations, promoting broadband deployment and adoption, and measuring broadband availability, adoption, and speeds.[2] As discussed below, Internet2 supports the Council's Notice and encourages it to incorporate the views of the research and education ("R&E") community into its efforts.

## Executive Summary

Internet2 respectfully submits that, as the country's premier National Research and Education Network ("NREN"), it is in a unique position to assist the Council's overarching goal of expanding the deployment of next-generation broadband to all Americans. The R&E community as a whole, including higher education, not only includes some of the most demanding Internet users in the country, but it has been at the forefront of developing the Internet into the most transformative technology of modern times. Because this community supports institutions of higher learning, which are such a vital part of the U.S. economy, it has a vested interest in helping to expand access to next-generation broadband services to support R&E. In addition, if higher education is going to continue to provide lifelong education to students, it will have to supplement its traditional teaching approaches with online learning. To do that successfully, higher education must reach students at home and at work with media-rich materials, which it can only accomplish through high-speed broadband networks.

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[1] Available at http://www.ntia.doc.gov/files/ntia/publications/fr_boc_notice_and_rfc_4-29-15.pdf ("Notice").

[2] *See* Notice, Questions B and H.

Given that the R&E community and the Council share the same objectives, as detailed below, Internet2 focuses its comments on the following three recommendations to assist the Council in its goals.

First, Internet2 recommends that the Council adopt policies that prioritize broadband abundance, specifically striving for network speeds in excess of 1 Gbps and networks that incorporate sufficient quality and reliability of service. As opportunities for global scientific research, increased delivery of government services online, and interactive digital learning continue to expand, Americans must have access to broadband service that keeps pace with new application demands to take advantage of these opportunities.

Second, the Council should adopt a forward-looking approach to U.S. broadband policies by supporting investments in infrastructure both domestically and globally. In developing these policies, the Council should address the limited coordination between the constituent agencies of the Council to avoid duplication of effort and to expand the level of coordination between the U.S. government and foreign governments and organizations regarding next-generation global network architecture. Additional American leadership and engagement is needed now to ensure that our country remains technologically and economically competitive far into the future.

Finally, Internet2 addresses the current need for the Council to support the development and deployment of a network performance measurement platform designed specifically for community anchor institutions ("CAIs"). Such a tool, among other things, will help national and local policymakers determine where best to devote scarce resources.

## **Background**

Internet2 is a member-owned, not-for-profit corporation founded in 1996 by the nation's leading higher education institutions. Today, Internet2 has grown to more than 476 members, including more than 282 research universities, government agencies and laboratories, private companies, and regional networks that provide advanced networking to a wide range of universities, government agencies, and CAIs. Through its position as the country's premier NREN, Internet2 promotes the next-generation R&E missions of its members by providing pioneering network capabilities and unique opportunities for cross-collaboration to develop innovative solutions to common technology challenges.

Internet2 has tremendous experience installing and managing next-generation broadband infrastructure, including having completed a $62.5 million Broadband Technology Opportunities Program ("BTOP") project. This project, funded by NTIA, helped to fulfill the recommendation of the National Broadband Plan that government agencies work with the R&E community to facilitate a "'Unified Community Anchor Network,' that would support and assist anchor institutions in obtaining and utilizing broadband connectivity."[3] Today, with this infrastructure in place, Internet2 serves as the backbone for state and regional networks that interconnect more than 93,000 CAIs throughout the country.[4]

Internet2 owns and operates a premier advanced national network infrastructure and identity management framework that serves a variety of constituencies within the R&E community. Using the latest generation of optical transport equipment, the Internet2 Network supports native 100 Gigabit services with near-term potential of offering 200 and 400 Gigabit services. Additionally, the Internet2 Network has advanced Layer 2 services built on software defined networking ("SDN"), which allows users to optimize the network for their specific

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[3] *Connecting America: The National Broadband Plan* at 154 (Rel. Mar. 16, 2010) ("NBP") available at http://www.broadband.gov/plan.

[4] Internet2's U.S. Unified Community Anchor Network program ("U.S. UCAN"), the outgrowth of its BTOP award, focuses on extending R&E network resources to all CAIs, thereby expanding access to, and ultimately adoption of, next-generation broadband.

application needs.[5] Internet2's current 8.8 Terabit capacity national network positions the Internet2 Network as one of the most advanced networks in the world. Internet2 has built its business models to encourage advanced applications to use bandwidth, eliminating per-unit billing systems in favor of investing in capacity in advance of demand. Internet2 also helps the R&E community select, develop, and deliver its own cloud and trust solutions through the NET+ program with commercial cloud service providers, maximizing the benefits of collaborative cloud environments and scale for academic institutions.

The Internet2 Network therefore is designed with intensive data users in mind. R&E networks, like the Internet2 Network and the networks operated by its state and regional partners, are uniquely designed and engineered to meet the needs of some of the most demanding Internet users in the country, namely scientists, academics, and researchers in the nation's leading academic and research institutions. These users have expectations that they can move massive amounts of data on demand, that the network will deliver a predictable throughput any time they offer a workload to the network, and that their network service provider will continuously expand the network to stay slightly ahead of the demand they are likely to generate.

Internet2's collaboration is extended not only by deep relationships with dozens of state and regional networks in the U.S. but also mission-driven networks in leading science agencies, such as the Department of Energy's ("DOE") Energy Sciences Network ("ESnet") and the National Oceanic and Atmospheric Administration's ("NOAA") science network, N-Wave. Internet2 also collaborates with federal agencies by providing network and membership services to the Department of Agriculture, National Institute of Standards and Technology, Centers for

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5 Internet2 has deployed the world's first SDN-based 100G network to reopen innovation in networking and ensure continued global leadership in the development of next-generation network technologies. This investment supports programs like the National Science Foundation Global Environment for Networking Innovations ("GENI") project and also provides a nationwide cyber-instrument to support scientists with data-intensive networking needs in the campus environment.

Disease Control and Prevention, National Institutes of Health, the National Park Service, and other federal agencies.

Internet2 has played an integral role in the shift toward global R&E collaboration, which has necessitated a fundamental change in how scientists and network providers interact.[6] The global information-age economy was born from the substantial investments in R&E here in the U.S., and Internet2 continues to play an active role in expanding the reach of its R&E members on a global scale. In fact, Internet2 has relationships with more than 65 foreign regional networks. These relationships include peering agreements to exchange traffic, with the goal of advancing science, networking, and cooperation between the foreign regional networks and user communities they serve.

## I. The higher education community has a vested interest in broadband deployment to all U.S. citizens.

### A. Higher education institutions are at the forefront of cutting-edge uses for broadband by some of the most intense broadband users in the country, including researchers, educators, and students.

Higher education institutions, as well as the R&E networks that support them, have played a seminal role in the creation, growth, and adoption of the Internet and the applications that have made it the most transformative technology in modern times.[7] The Advanced Research Projects Agency Network ("ARPANET"), the first real packet-switching computer network, was developed in 1969 primarily to foster communication between universities conducting high-tech

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[6] As one example, the Large Hadron Collider ("LHC") creates massive amounts of processed data, with a simulation output that creates even more data. In 2014 alone, the LHC program moved more than 250 Petabytes over the world's R&E networks, with much of this data moving to and throughout the U.S. Internet2 worked with ESnet and US LHCNet, which have provided transatlantic network connectivity from the LHC facility, to deploy networks with the bandwidth and capabilities to reliably transport multiple streams of 10 Gigabits of data per second. (As of January 2015, however, US LHCNet no longer supports the transatlantic network connectivity, and ESnet European Extension ("EEX") and its partner international networks have taken over its role.)

[7] *See* Notice, Questions D.16-17 (seeking comment on issues related to broadband adoption).

military research and defense contractors. Then in the early 1980s, universities partnered with the National Science Foundation ("NSF") to help create the Computer Science Network ("CSNET") and, later, NSFNET, which ultimately became the backbone of the Internet.

Since those early days, the R&E networking community has provided the platforms that created massive campus "innovation test beds" upon which campus network leaders and enterprising students developed some of the most influential Internet-based inventions. For example, Google (search) and Cisco (routers) started at Stanford University, Facebook (social media) at Harvard University, Twitter (social media) at New York University, and Akamai (network caching) at the Massachusetts Institute of Technology. Those are just a few of the developments in broadband applications and uses that have been discovered on U.S. campuses and then quickly deployed in the commercial Internet ecosystem. This, in turn, has led to the global transformation on which our current information-based economy is built.

At the research level, research universities currently perform more than 45 percent of all federally funded research. A key component to federally funded research is the information technology ("IT") and networking infrastructure supporting it – from high-performance computers ("HPC") processing enormous data sets to advanced gigabit networks transferring and combining the data sets for analysis. Just as laboratories and microscopes (and the corresponding utility costs involved in their operation) play a significant role in research and discovery, IT and advanced networking (and the corresponding infrastructure necessary for their operation) provide a foundation to promote scientific advancement. Moreover, major research campuses have recognized the growing trend of research involving large data file exchanges and remote collaboration requiring expanded broadband and interoperability on a global scale.[8]

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8 R&E networks also have supported basic science discoveries, such as the global search for the Higgs Boson particle and enabling the Mars Rovers to be managed by researchers across the

As for students, the higher education community realizes that today's students are dependent on broadband services for their education long before they reach college and that helping them access broadband will ensure that they come into the higher education system with a full complement of the skills necessary for success. Indeed, the number of options available to schools and libraries through massive online open courses ("MOOCs") and other online learning resources continues to grow daily. Students with sufficient broadband capability can now interact directly with teachers renowned in their fields, remotely access advanced scientific equipment located at research universities, or listen to or perform live with a symphony performance across the country in real time.[9] This technological and collaborative paradigm enables knowledge and expertise to flow seamlessly between higher education institutions and schools and libraries by providing limitless opportunities to expand and strengthen learning experiences for all researchers and students, no matter where they are located. Internet2 supports these efforts through its K20 Initiative, which develops programs and partnerships designed to

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globe. Further, the next generation of global climate science research demands that network connectivity make a strategic shift to a system that is solely dedicated to that purpose. To that end, since 2010, NOAA has partnered with Internet2 and its state and regional R&E networking partners to develop and deploy N-Wave, which serves to significantly enhance the capabilities of NOAA's researchers and their partners across the country. *See* N-Wave News at 4-5, available at http://noc.nwave.noaa.gov/uploads/a6/3d/a63d4dc0a90b80b507efa13e11411929/N-Wave-News-2-_11.2013.pdf. N-Wave is built on a set of dedicated waves on the Internet2 Network that enable NOAA to provide dedicated, high-speed, and high-capacity connections between climate and weather researchers and NOAA's key high-performance computing sites across the nation. As NOAA itself indicates, the Internet2 Network "support[s] large data flows that allow the users – scientists, researchers, and others – to easily share computational resources regardless of location." *Id.* at 4. *See also* Comments of The University Corporation for Advanced Internet Development (d/b/a "Internet2") at 9-11 filed in response to *Telecommunications Assessment of the Arctic Region*, Department of Commerce, National Telecommunications and Information Administration, Docket No. 140925800-4800-01 (filed Nov. 3, 2014).

[9] These opportunities also are possible for prominent American universities that are increasingly establishing campuses in Europe, China, Qatar, the United Arab Emirates and many other areas that are of geopolitical and economic interest to the United States.

leverage its advanced R&E networking infrastructure to deliver high-quality digital content and learning experiences to K-12 schools, public libraries, and other CAIs across the country.[10]

Increased broadband access and adoption will make these resources more readily available to more students. The possibilities for educational collaboration are endless and will greatly lower the costs of educating our students by allowing these experiences to take place right inside of the classroom, sometimes for hundreds or thousands of students at a time. Ultimately, by strengthening ties across the educational spectrum, we also strengthen our country's global economic competitiveness and leadership.

### B. Higher education institutions are vital to helping the U.S. achieve its broadband deployment goals.

Increasing high-capacity broadband access and adoption has benefited both the economy as a whole, and the higher education community and its students in particular.[11] Indeed, the success of both the U.S. economy and the higher education community are inextricably interlinked. As the Department of the Treasury and the Department of Education recently concluded in a joint report regarding the "complex public-private market" for secondary education, "[h]igher education is a critical mechanism for socioeconomic advancement among

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10 For example, the Presidential Primary Sources Project ("PPSP") is a program series developed by Internet2 in partnership with the National Park Service, Library of Congress, and National Archives and Records Administration Office of Presidential Libraries. At one event, students from across the country were able to participate in a real-time video conference with former President Jimmy Carter to discuss his contributions to the National Park System and his decision to protect more than 100 million acres of federal lands in Alaska while he was president. *See Nat'l Park Service Press Release*, President Carter to Share History of Alaskan National Parks, available at http://www.nps.gov/news/release.htm?id=1539.

11 *See* Notice, Question E.20 (seeking comment on what the federal government can do to assist state, local and tribal governments to access funding for broadband). As public research campuses are often among the biggest state employers and drivers of economic growth, the R&E community serves as a direct link between federal and state coordination with respect to broadband efforts.

aspiring individuals and an important driver of economic mobility in our society."[12] The report determined that students who completed two to four years of college received $2.4 trillion more in additional earnings in 2011 than they would have if they had just completed high school.[13] This represented 16 percent of the $15 trillion total gross domestic product ("GDP") for that year. In addition, in 2009, postsecondary institutions received $497 billion in revenue, representing 3.6 percent of the GDP, and employed 3.7 million workers, or 2.4 percent of the country's workforce.[14] International students studying in the U.S. and their families alone contributed $26.8 billion to the U.S. economy in the 2013-2014 academic year.[15]

In turn, public research universities and colleges rely on federal and state funding for a substantial portion of their operating revenue, as student tuition and fees account for only 40 percent of the total revenue for public institutions.[16] The higher education community thus is dependent on the economic success of the country to assure both public and private funding for education. President Obama reinforced this idea when he recently stated that "[w]e can't allow higher education to be a luxury in this country. It's an economic imperative that every family in America has to be able to afford."[17] The entire R&E community therefore wholeheartedly

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[12] *The Economics of Higher Education*, A Report Prepared by the Dept. of the Treasury with the Department of Education at 5 (Dec. 2012), available at http://www.treasury.gov/connect/blog/Documents/20121212_Economics%20of%20Higher%20Ed_vFINAL.pdf.

[13] *See id.* at 13.

[14] *See id.* at 7.

[15] *See* The International Student Economic Value Tool, available at http://www.nafsa.org/Explore_International_Education/Impact/Data_And_Statistics/The_International_Student_Economic_Value_Tool/

[16] *See The Economics of Higher Education* at 20; *see also Analysis of the Economic Impact & Return on Investment of Education* at 8 (noting that America's community colleges alone contributed $809 billion to the national economy, equal to approximately 5.4 percent of the nation's GDP), available at http://www.aacc.nche.edu/About/Documents/USA_AGG_MainReport_Final_021114.pdf.

[17] *See* https://www.whitehouse.gov/the-press-office/2012/02/27/remarks-president-national-governors-association-meeting.

supports the Council's objectives in this proceeding to continue investing in high-capacity broadband and removing barriers to such investment, which will lead to more economic growth and more educated students that are able to fill the high-skill jobs that this growth creates.[18]

There is an abundance of evidence demonstrating that broadband penetration enhances economic development. For example, the Federal Communications Commission ("FCC") recently concluded that broadband Internet access service serves as a "driver of economic growth" and "an engine of the virtuous cycle of broadband deployment, innovation, and consumer demand."[19] Similarly, the FCC noted in its National Broadband Plan that broadband access helps: (1) small businesses start up, expand, and improve more quickly and efficiently; (2) individuals gain new skills and access new opportunities; and (3) local communities attract new investment, industries, and workers. Further, based on Bureau of Labor Statistics data, the FCC has estimated that "jobs depending on broadband and information and communication technologies – such as computer systems analysts, database administrators and media and communications workers –will grow by 25% from 2008–2018, 2.5 times faster than the average across all occupations and industries."[20]

Studies establish that a 10 percent increase in broadband penetration can lead up to a 1.5 percent increase in economic growth, as measured by GDP.[21] Similarly, the Public Policy

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18 *See* Notice, Question A.6.

19 *In the Matter of Protecting and Promoting the Open Internet*, Report and Order on Remand, Declaratory Ruling, and Order at ¶ 329, GN Docket No. 14-28 (rel. Mar. 12, 2015), available at https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-24A1.pdf.

20 CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN, FEDERAL COMMUNICATIONS COMMISSION 265-66, 270-71, 273-74 (2010), available at https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf.

21 MARTIN CAVE, SPECTRUM AND THE WIDER ECONOMY 7 (2015) (collecting studies); *see also* Czernich et al., *Broadband Infrastructure and Economic Growth* 1 (CESifo Working Paper No. 2861, 2009) (testing the effect of broadband infrastructure on economic growth in Organization for Economic Co-operation and Development countries from 1996 to 2007 and finding "that a 10 percentage-point increase in the broadband penetration rate results in a 0.9-1.5 percentage-point

Institute of California found that broadband expansion is associated with employment growth, and that an analysis of the data demonstrates a causal relationship between the two – that is, broadband expansion leads to an increase in employment growth.[22] In fact, the Brookings Institution estimated that a one percentage point increase in broadband penetration would lead to "an increase of about 300,000 jobs" for the U.S. economy as a whole.[23] This economic growth in turn supports the success of U.S. higher education institutions, which depend on both public and private funding for educating the next generation of workers that can compete in the global economy.

But economic and employment growth cannot take place in a vacuum. Instead, the higher education community requires widespread broadband access both on campus and in students' residences in order to be able to deliver cutting-edge educational content to their students, who in turn can fill the new jobs created in an expanding economy. As the American Library Association and others recently noted in comments filed with the FCC, "higher education uses the public Internet to advance learning (both in-class and at a distance, including innovations such as massive open online courses, or MOOCs), research (especially around 'big data') and scholarly collaboration. Furthermore, the majority of college students live off-campus, which means that they rely on the availability of the public Internet for access to (increasingly media-rich) courses and learning resources, academic and student support, faculty

increase in annual per-capita [economic] growth."); Christine Zhen-Wei Qiang, et al., *Economic Impacts of Broadband*, *in* INFORMATION AND COMMUNICATIONS FOR DEVELOPMENT 2009 39, 44-45 (World Bank Group, 2009) (finding that "broadband connectivity had positive impacts on job creation, company and community retention, retail sales, and tax revenues.").

22 JED KOLKO, PUBLIC POLICY INSTITUTE OF CALIFORNIA, DOES BROADBAND BOOST LOCAL ECONOMIC DEVELOPMENT 22-28 (2010).

23 CRANDALL ET AL., BROOKINGS INSTITUTION, THE EFFECTS OF BROADBAND DEPLOYMENT ON OUTPUT AND EMPLOYMENT: A CROSS-SECTIONAL ANALYSIS OF U.S. DATA 2 (2007).

and peer collaboration, and more."[24] In addition, if higher education is going to continue to provide lifelong education to its students, it will have to support its traditional teaching approach with online learning. Online learning can improve the quality of education outcomes, enable more individualized educational experiences, and equip students with the skills needed to succeed in the global marketplace. To do all of that successfully, higher education must reach students at home and at work with media-rich materials, which it can only accomplish through high-speed broadband networks.[25]

Of course, the uneven distribution of access to, and adoption of, high-capacity broadband exacerbates the digital divide and leaves entire segments of K-12 students at a distinct disadvantage upon entering college or university.[26] Simply stated, in order to compete with their peers, students entering higher education institutions need to arrive with a full complement of skills related to using high-capacity broadband and the applications that run over those connections. As the U.S. Chamber of Commerce noted in a study analyzing the impact of broadband on education, less than half of all U.S. high school graduates are adequately prepared for college or for the workforce, and "[s]chools are generally failing to instill 21st century skills in students."[27]

To be prepared to enter college and ultimately to compete for jobs in today's globalized world, students must be able to use advanced information and communication technologies. Increasing access to high-capacity broadband at the earliest possible stage of *all* students'

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[24] Comments of the American Library Association, the Association of Research Libraries, and EDUCAUSE, FCC GN Docket No. 14-28, at 1 (filed February 25, 2014).

[25] *See* U.S. CHAMBER OF COMMERCE, THE IMPACT OF BROADBAND ON EDUCATION at 79 (2010), available at https://www.uschamber.com/sites/default/files/legacy/about/US_Chamber_Paper_on_Broadband_and_Education.pdf.

[26] *See* Notice, Question F.22 (seeking comment on how broadband technologies can be made more accessible to vulnerable populations).

[27] U.S. CHAMBER OF COMMERCE, at 3.

learning therefore is imperative to bridging the digital divide and "revers[ing] patterns of low achievement."[28]

### C. The best practices adopted by Internet2 and other R&E network operators can be leveraged to achieve the Council's goals.

The Notice seeks comment on how the federal government can "promote best practices in broadband deployment and adoption."[29] As discussed more fully in Section II.B below, the challenges to providing innovative networking solutions to common technology problems faced by Internet2 and the R&E networking community will be similar to those that may confront the Council in promoting advanced broadband infrastructure that will satisfy the data-intensive needs of the future. Rapid advancements in both computing and networking technologies and the applications that run over such infrastructure quickly can and do make what would appear to be high-capacity infrastructure today less than adequate in the near future.

The users of R&E networks, like the one operated by Internet2, have expectations that they can move massive amounts of data on demand, that the network will deliver a predictable throughput at all times they offer a workload to the network, and that their network service providers will continuously expand the network to stay slightly ahead of the demand they are likely to generate. The R&E community has had tremendous success operating networks that not only meet those needs today but also serve as the necessary testing grounds for the applications of tomorrow.[30] Internet2 and its state and regional networking partners therefore

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28 CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN, FEDERAL COMMUNICATIONS COMMISSION at 226, 232 (2010). Internet2 also recognizes that a comprehensive approach to broadband access should include investments in infrastructure in rural areas. Targeting rural areas not only will equalize educational opportunities but also help spur agricultural innovation (smart farming) and contribute to enhanced public safety, healthcare, and transportation systems throughout the country.

29 Notice, Question A.1.

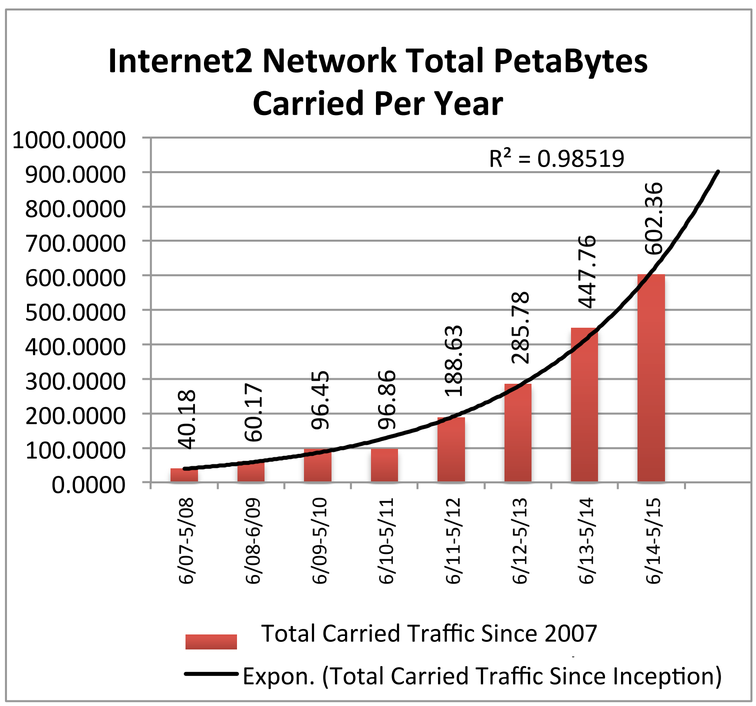
30 Internet2, through its U.S. UCAN program, has partnered with nonprofit organization US Ignite in its proposal to the NSF 15-508 US Ignite initiative focusing on the adoption of gigabit

have gained tremendous experience over time developing best practices that can be leveraged by the Council in deploying high-capacity broadband that will be future proof.

## II. The Council should establish policies and programs that prioritize broadband abundance.

### A. The Council should support broadband networks that offer unrestrained bandwidth and future-proof speeds.

Internet2 supports the goals of the White House's ConnectED initiative to ensure that 99 percent of students have access to speeds of no less than 100 Mbps by 2018.[31] However, Internet2 urges the Council to focus on policies that reach for the initiative's higher target of 1 Gbps and beyond. At the same time, while Internet2 recognizes that proposing to set a connectivity goal of 1 Gbps within the next five years would provide the Council with a readily available benchmark against which it can measure the success of deploying high-capacity broadband, Internet2 is wary that such benchmarks all too easily become the de facto standard. The result can be a perverse disincentive to achieve even greater results.




Unfortunately, no one knows what the appropriate connectivity speeds will be for 2018 and beyond. However, there is no doubt that unconstrained Internet usage has a

applications. Internet2 would be a sub-recipient to support the deployment and adoption of gigabit applications among CAIs in at least 15 cities, thus creating an "application test bed" community of CAIs.

[31] *See* Notice, Question F.22.

consistent pattern of doubling traffic approximately every one to two years. It therefore is without question that broadband technologies that cannot cost-effectively expand to support growing demand will not support the nation's future needs.

As the operator of one of the world's most advanced broadband networks, Internet2 does know that broadband connectivity well above 1 Gbps already is achievable today.[32] Rapid advancements in both networking technologies and the applications that run over those networks can and do quickly make what would appear to be a high-capacity broadband connection today less than adequate in the near future. The Council might consider setting both short-term and near-term (five-to-seven year) targets that create expectations for operators that anticipate bandwidth requirements in to the future. Whatever performance metric the Council chooses to target, it should take care that it does not have the unintended effect of causing the U.S. to shoot for the floor by settling for slower broadband speeds than are actually needed.

Because of this, Internet2 recommends that the Council give serious consideration to alternative methods for measuring the success of broadband deployment – methods that take into account constantly increasing, then-available, connectivity speeds and that encourage government agencies and private industry to strive for ever greater capacity. Advanced network applications, such as real-time instruction, will continue to use more and more bandwidth. CAIs and currently unserved or underserved populations face the risk of being unable to take advantage of the expanding opportunities for digital learning that are being built with cutting-

[32] For example, Vermont Telephone Company, Inc., or VTel, announced this month that it is introducing 10 Gbps broadband service to all of its residential subscribers. https://www.vermontel.com/about/newsroom/entry/vtel-rolls-out-10-gbps-internet-the-fastest-internet-in-vermont-just-got-1000-faster.

edge broadband connectivity in mind unless broadband capacity can keep pace with those applications.[33]

**B. The broadband networks of the future should offer sufficient quality and reliability.**

The Notice also seeks comment on actions that "would be most helpful to communities seeking to improve broadband availability and use."[34] Through its experience, Internet2 has found that the *quality and reliability* of service is just as important as the *quantity* of service, depending on the particular use to which broadband service will be utilized. In many respects, quality and reliability of broadband service is just as important as speed. Internet2 therefore respectfully submits that the Council should consider assessing factors that affect the quality and reliability of services that are tailored to the specific uses of broadband connectivity to ensure increased adoption rates. For example, to be successful, real-time, remote instruction and use requires broadband service that is low latency, has less jitter, and *eliminates* end-to-end packet loss.

Further, it will be important for the Council to understand the role that the quality and reliability of services plays in technological advances such as compute, storage, and network convergence. Recent breakthroughs in networking development have been based on advances in intelligent network design and software defined engineering through the power of cloud computing, where massive remote compute resources are seamlessly interconnected with broadband networks to allow end users to do more with the same broadband capacity. This type

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33 In this regard, Internet2 commends the efforts of the FCC to promote investments that support universal service and modify the program over time to keep pace with changes in technology and the evolving needs of users. *See, e.g., Modernizing the E-rate Program for Schools and Libraries*, WC Docket No. 13-184, Second Report and Order and Order on Reconsideration, 29 FCC Rcd. 15538 (2014) (permitting schools and libraries to use universal service funds to invest in dark fiber special construction projects).

34 Notice, Question A.1.

of capability will become even more essential as the "Internet of Things" – which reflects the ability to link smart devices to items such as automobile door locks and kitchen stoves – will require networks to become aware of the needs of users without human-to-human or human-to-computer interaction. To further facilitate a landscape that will help the Internet of Things to thrive, the Council should consider separating out the regulatory concepts of wired versus wireless networks. Such a separation does not contemplate an environment where compute, storage, and billions of devices are truly integrated and ultimately will be an impediment to the development of the Internet of Things. Internet2 urges the Council to broadly view broadband as a facility that enables the convergence of both wired and wireless networks with users, data centers, and intelligent devices in a seamless integrated environment.[35]

R&E networks are at the cutting edge of network convergence and the development of quality and reliability standards needed for this to occur. R&E networks increasingly are designed with the integration of compute, storage, and end-users envisioned across a high-quality and high-reliability network: abundant symmetrical bandwidth, low latency expectations, and low jitter guarantees that do not inhibit users' connections and that allow plenty of headroom for bursting applications without needing to cap users' throughput for flash usage events. Indeed, early in Internet2's history, it established a series of headroom policies to ensure that the connectivity it provides functions correctly, no matter the use to which it is put. Although Internet2 concluded that many applications simply require abundant bandwidth, it also determined that many advanced applications require qualitatively different connections to

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35 Of course, the convergence of networks enabled primarily through advances in software engineering and quality and reliability standards is only one piece of the puzzle. Broadband abundance – both in terms of geographically increasing broadband deployment and increasing capacity where broadband is already deployed – also is essential. As more and more people and things connect to the Internet, we must ensure that investments in broadband infrastructure go to scalable, future-proof technologies such as fiber in order to avoid demand outpacing capacity.

function correctly, such as maximum packet-delay (latency) guarantees and consistent, predictable paths for network traffic that best-effort networks are unable to provide.[36]

For example, remote collaborative applications include requirements based on hard thresholds of human perceptual sensitivity that translate into very specific latency and jitter needs, particularly with respect to the performance arts. The Internet2 Network optimizes its paths to bring latency as close to the speed of light as possible, assuring that collaborative applications can work at the maximum distance between collaborators.[37] Failure to design latency expectations into the network results in the application being reduced to smaller collaborations that are degraded or even unusable, thus decreasing the likelihood that broadband adoption is maximized. The Council thus should be cognizant of the fact that connectivity speed is only one piece of the high-capacity broadband puzzle, and traditional best-efforts services are incapable of meeting the needs of advanced applications.

## III. The Council should support a forward-looking approach to the nation's broadband policies that prioritizes next-generation infrastructure and ensures that the country remains technologically and economically competitive.

Internet2 respectfully submits that in considering ways "to promote public and private investment in broadband," the Council should focus not on adoption of current broadband technologies, but on the requirements to enable continuous deployment of next-generation network infrastructure that can be deployed, both domestically and abroad, in a manner that is useful to scientists, supportable by technologists, essential to education, and sustainable beyond

[36] In a best-efforts network, each network element along an IP packet's path makes nothing more than a good-faith effort to forward the packet toward its destination. If a router's queue is overloaded, packets are dropped with little or no distinction between low-priority traffic and urgent traffic.

[37] For example, Internet2 has demonstrated technology that enables real-time, simultaneous, live musical performances across long distances featuring low-latency audio and videoconferencing technology, https://www.youtube.com/watch?v=vZ0xSb8mz6o. *See also* Internet2 Press Release, available at *http://www.internet2.edu/news/detail/2511/*.

the course of short-term funding.[38] The next generation of research, for example, which will determine the country's future economic competitiveness in an increasingly global market, will rely on distributed knowledge environments spread across geographic boundaries. The rise of data-intensive scientific research truly is a global phenomenon, with international collaborations becoming ever more important and increasingly the norm.[39] The rapid growth of scientific data (from, for example, genomic sequencers, new telescopes, and sensor networks) and the progressively international scope of R&E activities require significant increases in international network capacity and a new approach to network architecture and deployment. R&E networks create a networking environment that allows for these big data endeavors to function seamlessly. They also serve as an innovation platform for new technologies and allow academic and scientific leaders to work in a collaborative environment to develop common solutions to the world's most pressing challenges.

High-performance networks, such as the Internet2 Network, allow scientific endeavors to flourish across multiple fields, accelerate research discovery, advance national and global education, and improve the delivery of public services. However, the global R&E network architecture will need to be upgraded and streamlined to keep pace with the demands that scientists and researchers increasingly will place on their networks. Therefore, investments in this advanced networking infrastructure will have far-reaching impacts and should be a priority for the Council.

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[38] Notice, Section II.

[39] *See* Comments of The University Corporation for Advanced Internet Development (d/b/a "Internet2") at 4-10 filed in response to the Interim Report issued by the National Research Council's Committee on Future Directions for NSF Advanced Computing Infrastructure to Support U.S. Science and Engineering in 2017-2020 (filed Jan. 30, 2015).

### A. Agencies that are involved in funding broadband projects should permit funding for broadband infrastructure projects by consortia and public-private partnerships.

Internet2 respectfully submits that funding methodologies and practices utilized in certain federal programs have not yet allowed for the development of cohesive, cost-effective solutions to making broadband available to all Americans or to building next-generation global network architectures.[40] Internet2 therefore recommends that the Council should focus on increasing collaborative investments, such as the coordination of public-private partnerships to fund investments both domestically and globally.

NSF, for example, has utilized these partnerships to great success in the past, with the immediate predecessors to Internet2 serving as some of the best examples. In the mid-1980s, NSF awarded a contract to a partnership that included Merit Network, IBM, MCI, and the State of Michigan to upgrade NSFNET to T-1 speed (1.544 Mbp/s) and to connect NSFNET to several other research networks. In 1995, NSF signed a cooperative agreement with MCI to create the very high speed Backbone Network Service ("vBNS"). The vBNS facilitated advanced networking research and the development of new technologies, such as IPV6, to support advanced applications. Both of these projects paved the way for the Internet as we know it today. More recently, NTIA's BTOP program successfully leveraged public-private partnerships to help achieve the nation's broadband goals. The BTOP program required all recipients to provide matching funds toward the total cost of their broadband infrastructure, adoption, and training projects. As a recent study found, the program has resulted in billions of dollars in economic benefits, higher levels of employment, and higher-than-average broadband

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40 *See* Notice, Question B.14 (seeking comment on ways to better coordinate federal programs).

penetrations in the communities served by the projects.[41] The Council should identify and pursue similar funding opportunities that encourage collaborative investments, including federal government programs, private sector efforts, and opportunities for interagency coordination related to funding future-proof broadband infrastructure.

### B. Agencies sponsoring research and development activities and programs should ensure that federal funds can be used for advanced broadband infrastructure.

As noted above, universities perform more than 45 percent of all federally funded research, and generally recover research and development and administrative-related federal research costs through an indirect cost rate that is negotiated between the university and the responsible federal agency funding the majority of that campus's research based on review of previously incurred costs.[42] It is critical to ensure that these indirect cost rates are inclusive and sufficient to support each institution's IT and advanced networking costs, in order to support current and future research. This also will ensure that the information and communications technology infrastructure is maintained and evolved with the advance of technology and the increasing pace of research data capacity requirements. In addition, it is critical that relevant federal agencies, such as NSF, continue their recent campus cyberinfrastructure investments in order to facilitate and accommodate the rapid pace of research discovery and the corresponding network capacity needs.

Major research campuses have recognized the growing trend of research involving large data file exchanges, high-performance computing, and remote collaboration requiring expanded broadband and interoperability. In fact, these major research universities have accompanied federal cyberinfrastructure investment with sustainable investments of their own. In order to

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[41] *See* Broadband Technology Opportunities Program Evaluation Study at 3-4 (2014), available at http://www.ntia.doc.gov/files/ntia/publications/asr_final_report.pdf.

[42] *Id.*

achieve long-term sustainability of research cyberinfrastructures without disrupting the pace and scope of research inquiry, it is critical that the Council and its constituent agencies continue their existing investments in cyberinfrastructure and recognize the critical importance of network connectivity and capacity costs in formulaic negotiations of indirect cost recovery.

### C. The Council should encourage U.S. leadership and investments to establish a shared global fabric for next-generation networking.

On a global scale, the Council should increase the level of cooperation between the U.S. Government and foreign governments and organizations that are interested in advanced networking solutions.[43] Collaboration and coordinated investments will be essential to establish a shared global fabric for next-generation networking and ensure that U.S. R&E institutions can participate fully in global science research and instrumentation. As the federal government has recognized, "American companies and businesses require a highly skilled workforce to meet the demands of today's increasingly competitive global economy."[44] To educate highly skilled workers capable of competing in this environment, the U.S. R&E community needs to be connected to a truly global network. As a result, the R&E community encourages the Council to strategically align federal government leadership and investments in global R&E networking.

In many countries, governments take an active role in funding their national R&E networks.[45] Many foreign governments also make significant investments to connect their R&E

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[43] *See* Notice, Section II (seeking comment on ways the federal government can promote coordination).

[44] *The Economics of Higher Education* at 2.

[45] For example, the European Commission has provided more than €300 million in grant funding to the Delivery of Advanced Network Technology to Europe (DANTE) organization, which built and operates the European NREN, GEANT. *See* http://www.dante.net/Research_Networking/European_Commission/Pages/Home.aspx. In addition, the Council of the European Union recently adopted a resolution recognizing the importance of high-performance computing ("HPC") infrastructure for research and the need to develop the next generation of HPC technologies and calling for an exploration into mechanisms for better coordination of member states' investment strategies in e-infrastructure. *See* Council Conclusions on

networks to networks in other countries. In fact, in recent years the European Commission has devoted significant funding to allow the pan-European networking organization Delivery of Advanced Network Technology to Europe (DANTE) to connect its network to South America, northern Africa, South Africa, Asia, and the United States.[46] China has made similar investments to connect its national R&E network to regional and global cyberinfrastructure.

As many NRENs now work to transition from a purely national viewpoint to having a global reach, they are eager to work with the U.S. to create a coherent global networking infrastructure to propel broadband deployment and adoption into the future. The U.S., however, has not yet initiated this type of grand-scale collaboration, despite the fact that the creation of comprehensive and rationally designed global network architecture is dependent on the contributions of many countries, regions, and organizations, and the key role that NRENs around the world are looking for the U.S. to play.

Increasing U.S. involvement in global networking initiatives would have far-reaching impacts and should be a priority for the Council. For example, the Internet is an extremely powerful economic development engine. NRENs, like the Internet2 Network, can connect developing countries so that they can experience the Internet's transformative qualities, while at the same time creating new markets for U.S. businesses. Enhanced global R&E network infrastructure also will enhance and safeguard the impact of the Internet in developing

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Open, Data-Intensive and Network Research as a Driver for Faster and Wider Innovation, at 8, available at http://data.consilium.europa.eu/doc/document/ST-9360-2015-INIT/en/pdf.

[46] The European Commission has provided millions in funding to support and connect NRENs across the globe with GEANT. In particular, the European Commission has provided €29 million to the Trans-Eurasia Information Network (TEIN4) in the Asia-Pacific region, €18 million to the RedCLARA network in Latin America, and €11.8 million to AfricaConnect in Southern and Eastern Africa. *See* https://ec.europa.eu/europeaid/regions/asia/tein-3_en; http://alice2.redclara.net/index.php/en/component/content/article/3-destacado/7-otra-noticia-destacada; http://www.africaconnect.eu/Project/Pages/Funding.aspx.

and politically at-risk countries, as open R&E networks foster a safe haven for political dialogue and intellectual freedom. Further, a next-generation global R&E network architecture can ensure that American students studying overseas have access to the same level of open and reliable networking that they enjoy at home, and that foreign students can benefit from the cutting-edge technological capabilities they have come to expect from U.S. academic institutions. In addition, as noted above, modern research problems are growing more complex, and global-scale scientific collaborations and funding models are becoming the norm. NRENs connected to each other create a networking environment that allows big data endeavors to function seamlessly and serves as an innovation platform for new technologies.

In the short term, the Council should support public-private efforts to fund acquisition of a bulk capacity known as “wet optical fiber pairs” between continents in order to link NRENs in a more robust, cohesive, and future-proof manner. From a longer-term perspective, the Council should consider the role it could play in developing a coordinated strategy for the acquisition and operation of global cyberinfrastructure. Activities that will help to develop global broadband infrastructure should include establishing a global network backbone to meet aggregated demand; designing the architecture of “open exchange points” throughout the world; and establishing a governance model for building and supporting the global network of the future. These very issues are being addressed now through the Global R&E Network CEO Forum, which comprises executive leaders from a range of leading national and regional R&E networks around the world, including Internet2. These leaders meet periodically to strategically address the future of global networking requirements, and Internet2 would gladly coordinate with the Council to increase the Council’s engagement with the forum.

The Council therefore should focus on more coordinated leadership and investment across federal programs towards U.S. interests in the development of enhanced global R&E network architecture. By creating mechanisms for ongoing and informed dialogue both within the U.S. and between the U.S. and global R&E networking communities, future R&E networking investments will be more efficient, future global collaborative efforts will be more sustainable, and global network-enabled science and support for network research activities will be dramatically enhanced. In the process, a rationally architected network, services, and community of collaborators will enhance the work of stakeholders in U.S.-funded activities.

### D. The Council should facilitate increased coordination among U.S. federal agencies in addressing the country's broadband needs.

At the domestic level, current activities within the U.S. government appear to be disjointed. The Council therefore should address the coordination between and among U.S. agencies that fund, use, and deploy broadband infrastructure.[47] For example, the U.S. Budget FY 2016 includes requests for funding of approximately $2.4 billion for broadband initiatives within at least six separate agencies, including the following

- NSF requests $143 million to support the Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education, which will accelerate and transform the process of scientific discovery and innovation by providing advanced cyberinfrastructure and new capabilities in computational and data-enabled science and engineering. (NSF Budget Fact Sheet).

- The Department of Education requests $300 million to support innovation in K-12 and postsecondary education. (U.S. Department of Education, FY 2016 Budget Fact Sheet, p. 2).

- The Department of Interior requests $41 million to extend broadband Internet and computer access to all schools and dormitories funded by the Bureau of Indian Education, with support from NTIA's community broadband outreach program. (U.S. Budget, FY 2016, p. 38).

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47 *See* Notice, Question A.11 (seeking comment on ways to better coordinate federal funding between agencies).

- The Budget provides $242 million for the National Strategic Computing Initiative within DOE to promote innovation in high-performance computing to support national security, scientific discovery, and economic competitiveness. (U.S. Budget, FY 2016, Analytical Perspectives, p. 297).

- The Budget provides $690 million to support USDA's Telecommunication Loan Program for the improvement and construction of telecommunication facilities in FY 2016. USDA also requests $792 million in loan guarantees and direct loans to support new community infrastructure. In addition, the Budget also provides USDA with another $89 million in broadband loans and grants (FY 2016 USDA Budget Summary, p. 46; U.S. Budget, FY 2016, Analytical Perspectives, p. 313-14).

- NTIA requests $13 million in support of broadband programs. NTIA will redirect a portion of its base budget to continue the momentum of the BTOP grant program by providing sustained technical assistance and outreach to a diverse set of communities and stakeholder groups to strengthen broadband capacity, economic opportunities, and innovation. (U.S. Budget, FY 2016, Appendix, p. 213).

As this sampling illustrates, the amount of money that the U.S. invests in broadband-related initiatives could be more effective if certain federal broadband goals and programs were consolidated. The Council thus should seek out ways to streamline and centralize the broadband activities and funding efforts of the federal government. This will make broadband investments more effective, avoid duplication of efforts, and identify synergies across agencies. In addition, by involving campus researchers in its coordination efforts, the Council can amplify federal investments by supporting the types of networking systems that truly meet researchers' needs.

## IV. The Council should support the development of a nationwide network performance measurement platform for CAIs.

The Council seeks comment regarding the variance in broadband speed definitions.[48] Internet2 respectfully submits that a more fundamental issue exists regarding how broadband capacity is measured, and not simply how speeds are defined. Indeed, broadband testing is a critical tool used by policymakers to understand residential broadband adoption and to

48 *See* Section III, Question 8.

understand the speed tier and quality of broadband used in households. However, the tools that currently are used to measure residential speeds are insufficient for measuring broadband capacity and performance at the CAI level. In order to assess where improvements can achieve the greatest return on investment at the CAI level, the Council should focus on supporting the development and adoption of a broadband speed-measuring tool designed specifically for CAIs.

Today, there are two prominent broadband speed-testing tools provided by Ookla and Network Diagnostic Tool ("NDT"), which are used by the FCC's speed test initiative. Given their focus on measuring residential broadband connections, these tools do not provide consistently accurate results in CAI networking environments. The problem is that either the testing algorithms used are proprietary or the tools are architected to use testing protocols that do not work well in CAI networking environments, which often are heavily firewalled and include network address transition ("NAT") configurations (in which multiple computers or network devices are connected via a single IP address). As a result, these test results cannot be validated independently and are otherwise insufficient for CAI networking environments.

In order to accurately understand CAI broadband environments, the Council should support the development, deployment, and adoption by CAIs of an open-source network performance measurement platform specifically designed to assess CAI broadband performance and connection quality. Such a tool can be operated on a national scale and serve as a trusted source for impartial and authoritative information on CAI broadband connectivity, supporting federal, state, and local broadband policy decisions. Indeed, through supporting the development and adoption of a scalable, long-lived measurement platform, the Council would obtain a mechanism to collect complete, accurate, and consistent data on current CAI broadband connectivity, as well as longitudinal data to inform the Council's strategy and investment decisions by highlighting, for example, regions and/or CAI sectors that have not adopted robust broadband connections. This platform also could be leveraged to monitor universal service fund investments, specifically the E-rate-subsidized connections to schools and libraries, to ensure that they are providing the speeds and quality of service that are in the service level agreement.

CAIs will benefit from using a CAI-focused platform by broadening their understanding of how they connect to the Internet or the types of applications and services they can and cannot support given their current broadband speeds and quality characteristics. Further, this tool and related broadband characteristic education platform would raise awareness about how the R&E networking community can help CAIs better serve their communities through advanced broadband applications.

In sum, this measurement initiative would better inform national, regional, and local policy development and broadband investment, provide a baseline against which improvements to CAI connectivity might be compared, and provide a platform for CAIs to better evaluate their own network performance.

## CONCLUSION

For the reasons outlined above, Internet2 fully supports the Council's review of these important broadband issues and looks forward to working with the Council to achieve its goals.

Respectfully submitted,

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